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LOW-CALORIE FOOD
[Tei karori- shokuhin]

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Specifications /279*

1. Title of the Invention

LOW-CALORIE FOOD PRODUCTS

2. Claim(s)

1. Low-calorie food products comprising an indigestible polyol fatty acid polyester, and an archorrhea-preventing agent selected from a group of nonfermentable dietary fibers having a mean particle length of 50 μm or longer.

2. The food products of Claim 1 wherein the particle length falls in a range of from 100 to 200 μm.

3. The food products of Claim 1 or 2 comprising 2 to 50 % by weight aforesaid dietary fibers.

4. The food products of any one of Claims 1 to 3 wherein the total fat content in the food products is 10 to 50 % by weight.

5. The food products of any one of Claims 1 to 4 wherein the aforesaid polyol fatty acid polyester has 30 to 100 % by weight total fat content.

6. The food products of any one of Claims 1 to 5 wherein the ratio of the aforesaid dietary fiber and the aforesaid polyol fatty acid polyester is 1:4 to 2:1.

7. The food products of any one of Claims 1 to 6 wherein the mean invert ratio of the aforesaid polyol fatty acid polyester is 95% or higher.

8. The food products of any one of Claims 1 to 7 wherein the aforesaid polyol fatty acid polyester is derived from a fatty acid source selected from a group comprising palm oil, partially hydrogenated palm oil, palm

* Number in the margin indicates pagination in the foreign text.

kernel oil, partially or completely hydrogenated palm kernel oil, soybean oil, partially hydrogenated soybean oil and partially or completely hydrogenated marine product oils.

9. A nonfermentable dietary fiber used as an archorrhea-preventing agent in low-calorie food products comprising an indigestible single-blend polyol fatty acid polyester.

10. A nonfermentable dietary fiber used as an archorrhea-preventing agent in low-calorie food products comprising an indigestible single-blend polyol fatty acid polyester and having a mean particle length of 50 μm or longer.

3. Detailed Specifications

The present invention relates to low-calorie food products /280 an indigestible polyol fatty acid polyester.

30 to 50% of the energy intake by Westerners is attributable to the consumption of fats and oils. About 40% of this intake is consumed as "visible" fats, such as butter, margarine, lard, shortening and cooking oil, and in particular, various baked products, such as pastries, biscuits, cakes, cream-filled articles and snacks.

Because of obesity and the risk to health by poorly balanced fat intake, there is incessant interest in reduced-calorie food products. A fascinating means for reducing the calories of food products, and in particular, baked products and snack products replaces conventional digestible oils and fats with indigestible fats and oils.

It is known that sugar fatty acid polyesters, such as polyol fatty acid polyesters, and in particular, sucrose fatty acid polyesters are

suitable as low-calorie substitutes for food products. These polyol fatty acid polyester substitutes are actually indigestible by humans, and have physical and functional properties substantially resembling triglyceride fats and oils which have been used conventionally in food products. A polyol fatty acid polyester has the ability to capture fat-soluble substances, such as cholesterol, in the gastrointestinal tract and subsequently remove such substances from the human body; hence, it is reported a polyol fatty acid polyester has medical applications.

Fat-containing food products comprising indigestible polyol fatty acid polyesters are known, such as recited in U.S. Patent Nos. 3,600,186, 4,005,195, 4,005,196 and 4,034,083, and European Patent Nos. 0233856 and 0235836.

In addition to the risk to health connected to a poorly-balanced fat intake, it is believed that the intake of dietary fibers is too restricted in the daily meals of the average Westerner and adversely affects overall metabolism. Consequently, reduced-calorie food products which comprise a certain amount (or more) of dietary fiber is attractive.

A baked product comprising a liquid polyol fatty acid polyester and microcrystalline cellulose are described in U.S. Patent No. 4,461,782. A certain amount of fatty acid having a sufficiently high melting point is contained as medicine for preventing archorrhea (e.g., liquid polyesters leak freely through the anal sphincter) which can occur due to intake of a considerable amount of the liquid polyester in the baked food.

By combining the liquid polyol fatty acid ester and the microcrystalline cellulose as described, the calories can be greatly reduced, but the fact

that it is necessary to contain a solid fatty acid is not desirable, in view of the existing general understandings related to the influence on health by the use of highly saturated fatty acids and fats, in view of those influences having the opposite effect on calorie reduction, and from the standpoint that the compositional freedom is restricted.

Dough-based products comprising 0.1 to 5 % by weight of a filler having a thixotropic, cohesive mesh structure, with cellulosic fibrils or microfibrils dispersed in an aqueous phase of the product, are described in U.S. Patent No. 4,774,095. Disclosed is the fact that the particle length of the above-mentioned fibrils normally falls in a range of from 10 to 1,000 μm, with the majority of the fibrils having a length of from 100 to 250 μm. Dough for the above-mentioned product contains shortening. However, this shortening comprises a nonabsorbable and indigestible polyol fatty acid ester and the archorrhea-preventing agent described in U.S. Patent No. 4,005,196.

The addition of the archorrhea-preventing agent, such as the solid polyol fatty acid polyester described in U.S. Patent No. 4,005,196, also has drawbacks because of the increase in calories and the intake of saturated fatty acid. But as a result of intaking a considerable amount of high-melting point (higher than body temperature) polyester, it is also thought perhaps constipation occurs along with archorrhea. As a consequence, the addition of these compounds depends on the recipe of the finished good and it cannot be said that this is attractive in any case.

It was then proven that the fiber itself can be used conveniently for eliminating or reducing all the problems of archorrhea in low- /281

calorie products comprising polyol fatty acid polyesters (in particular, when the fiber is selected based on the fact that the particle length of the fiber is relatively long).

It was proven that the use of dietary fiber in such applications, and in particular, selecting it, on such a basis, eliminated or greatly reduced the two problems of archorrhea and constipation.

If dietary fiber is contained in accordance with the present invention, a polyol fatty acid polyester can be selected without paying attention to the potential problems pertaining to archorrhea. As a result, optimization of the properties of the prescribed low-calorie food products and the required conditions can be improved even more.

Therefore, the present invention relates to application of nonfermentable dietary fiber as an archorrhea-preventing agent in low-calorie food products comprising an indigestible single-blend polyol fatty acid polyester.

In another embodiment, the present invention relates to the application of nonfermentable dietary fiber having a mean fiber length of 50 μm or higher as the archorrhea-preventing agent in low-calorie food products comprising an indigestible polyol fatty acid polyester.

In yet another embodiment, the present invention relates to a low-calorie food product comprising an indigestible polyol fatty acid polyester and an archorrhea-preventing agent selected from a group of nonfermentable dietary fibers having a mean particle length of 50 μm or longer.

The dietary fiber suitable for use in the food products of the present invention is a nonfermentable dietary fiber, i.e., a variety of dietary fibers not substantially fermentably decomposed by the bacteria in the large intestines.

In these specifications, "not substantially fermentably decomposed" means that less than 30 % by weight of the initial intake of the fibers are not decomposed fermentably.

Lignin fibers, which are three-dimensional nonpolysaccharide polymers containing phenyl propane units derived from sinapyl alcohol, cinnamyl alcohol or p-coumaryl alcohol; cellulose fibers, which are linear polysaccharides in which β-glucose linked by 1,4 bonds forms the basic unit; and fibers in which hemyl cellulose, which is a group of heterogenous polymer compounds composing the part dissolved in a weak alkali after removing the pectin in the plant cell walls and composed of either β-glucose or xylose as the main chain are cited as typical examples of such nonfermentable dietary fiber. In particular, it was proven that the cellulose nonfermentable dietary fiber was suitable for use in the present invention.

The nonfermentable fiber source suitable for use in the present invention may be a chemically-improved fiber product, such as microcrystalline cellulose obtained by partial acid hydrolysis of natural substances, such as wood, cotton and food product raw materials, natural food product raw material or processed (waste) substances, or, e.g., natural cellulose.

The raw materials and chemical structures of fermentable dietary fibers are not essential to that extent, and preferably, the mean particle length of the nonfermentable dietary fiber is 50 μm or higher, more preferably, 80 μm or higher. Most preferably, it falls in a range of from 100 to 200 μm.

In these specifications, the term "mean particle length" indicates the number average particle length of the entire fiber length distribution considered the top of the particle length distribution per 99 % by weight of the fiber composition.

The amount of the nonfermentable dietary fiber contained in the low-calorie food products of the present invention is 60 % by weight or less of total food product. Even though it depends on the type of the finished good and the amount of polyol fatty acid polyester and even if the amount of the fiber substance is low at 1 % by weight, this already has the effect of omitting the risk of archorrhea. If the amount of the fiber substance exceeds 2 % by weight (in most cases, 5 to 50 % by weight), this has an effect for preventing the risk of archorrhea and constipation even if the concentration of the polyol fatty acid polyester is relatively high.

For example, if a high concentration of fiber is present as in meat products, in finished goods the amount falling in a range of 2 to 15 % by weight, and in particular, 5 to 10 % by weight is preferred. An amount of 10 to 50 % by weight, and in particular, 25 to 50 % by weight of fiber in the finished good is preferred.

The present invention is based on a finding that nonfermentable fiber can be used very conveniently as an archorrhea-preventing agent. Usually these fibers are used singly as medicine for preventing or /282 drastically reducing archorrhea and/or constipation events potentially associated with the use of a considerable amount of indigestible polyol fatty acid polyester.

However, the need to contain a relatively limited amount of a solid having a higher melting point than body temperature, e.g., a so-called known hard stock in conventional fat technology sometimes develops for product rheology reasons. In most cases, such a hard stock is contained as a portion of the indigestible single-blend polyol fatty acid polyester constituent which will be described in detail below.

The second essential constituent in the low-calorie food products of the present invention is an indigestible polyol fatty acid polyester substituted partially or completely with a conventional triglyceride fatty acid constituent.

The indigestible polyol fatty acid polyester is a fatty acid polyester derived from an aliphatic or aromatic compound comprising at least four free hydroxyl groups. A sugar comprising at least four free hydroxyl groups (e.g., monosaccharide, disaccharide or polysaccharide), a polyol sugar group comprising the corresponding sugar alcohol or its derivative is contained in such polyol. Glucose, mannose, galactose, xylose, fructose, sorbose, tagatose, ribulose, xylulose, maltose, lactose, cellobiose, rhaffinose, sucrose, erythritol, mannitol, lactitol, sorbitol, xylitol and methyl glucoside can be cited as examples of preferred polyol sugars.

An average 70% or more of the hydroxyl groups of the polyol of suitable indigestible polyol fatty acid polyesters are esterified by a fatty acid. Preferably, a polyol fatty acid polyester having a higher invert ratio, and in particular, a polyol fatty acid polyester in which an average 95% or more, and further, 95% or more of the hydroxyl groups of the polyol esterified by a fatty acid is used.

For the objects of the present invention, "indigestible" (a term connected closely to the degree of esterification and the chain length of the fatty acid residue) means that about 70 % by weight or more of the substance thereof is not digested.

A fatty acid itself or a natural oil or fat can be used for the fatty acid residue source in the polyol fatty acid polyester. A suitable fatty acid blend is selected according to the melt characteristics demanded of a polyol fatty acid polyester obtained in particular. But normally it is a blend of fatty acids having 8 to 22 carbons. If needed, a conventional technology for providing the desired melt characteristics may be used. Complete or partial hydrogenation, interesterification or transesterification, and discrimination are included for such a suitable technology, and it may be performed before or after inversion of the polyol to a polyol fatty acid. A suitable fatty acid residue source is derived from animals, marine animals, or vegetables, such as coconut oil, palm kernel oil, palm oil, butterfat, soybean oil, safflower oil, cottonseed oil, rapeseed oil, poppyseed oil, corn oil, sunflower oil, peanut oil, marine products oil and their mixtures. The preferred fatty acid residue source includes palm oil, partially hydrogenated palm oil, palm kernel

oil, partially or completely hydrogenated palm kernel oil, soybean oil, partially hydrogenated soybean oil, and partially or completely hydrogenated marine product oil.

In these specifications, the polyol fatty acid polyester mixture obtained by a one-time synthesis reaction of a suitable blend of one kind of polyol and a plurality of fatty acid residues is called a single-blend polyol fatty acid polyester. In place of this single-blend polyol fatty acid polyester (the fatty acid residue on the polyol molecule is thought to be randomized), a mixture or a blend of polyol fatty acid polyesters synthesized separately can be used. The blend of polyol fatty acid polyesters synthesized separately corresponds to a fatty acid residue on a polyol that is (partially) distributed nonrandomly. Selection of a single-blend polyol fatty acid polyester or a polyol fatty acid polyester is determined, depending on the desired dissolving characteristics /283 and rheology of the low-calorie food products.

The polyol fatty acid polyester preferably contained in the low-calorie food products of the present invention is characterized by a melt profile corresponding to both a fraction which is a liquid and a fraction which is a solid, in at least a part of a temperature range between room temperature and about 40°C.

The amount of indigestible polyol fatty acid polyester constituent contained in the low-calorie food product is at the substituted fatty acid level of 10 to 100 % by weight based on the weight of the entire aliphatic content of the product. A level of 30 to 100 % by weight or a substitution level of 50 to 100 % by weight is preferred.

As compared to the recipes of the finished goods specified below, and in particular, the fiber to polyester ratio, a conventional fat constituent that can be substituted wholly with a polyol fatty acid polyester is most preferable.

The finished good preferred as an embodiment of the present invention has a total fat content equivalent to 10 to 50 % by weight of finished good.

The absolute concentration of the fiber constituent and the polyester constituent is important for obtaining the health benefits associated with their use, but in order to reliably obtain an optimal effect, the relative amounts of these constituents contained is important according to the present invention. The preferred weight ratio of the fiber to the polyester falls in a range of from 1:4 to 2:1, but a ratio of from 1:2 to 1:1 is most preferable.

In the preferred embodiment, the dietary fiber constituent of the low-calorie food products of the present invention is mixed with an equal amount of the polyester constituent or it is aggregated with the polyester constituent. A polyester coating is applied to the fibers accordingly. This coating contributes to a food product's taste because it completely conceals a bad texture latently associated with the relatively high concentration of fiber constituent.

In order to provide a low-calorie food product further reduced in calories in the sweet or sweetened low-calorie food products categories, such as chocolate products, candy products, cakes and biscuits, it is also useful to use an artificial sweetener or a low-calorie sweetener

jointly with the indigestible polyol fatty acid polyester constituent and the nonfermentable dietary fiber. Compounds suitable as applicable artificial sweeteners or low-calorie sweeteners include aspartame (phenylalanine), saccharin, cyclamates and thaumatin. 0.1 to 5 % by weight of these compounds are usually contained in the food product.

The use of a slow-digesting sweetener, such as sorbitol or fructose, by combining the indigestible hard fat substitute of the present invention is of deep interest to provide low-calorie food products especially suitable as medically-therapeutic foods. The amount of concerned sweetener contained is at the same level as a conventional saccharide, e.g., 30 to 55 % by weight of the final product.

In addition to the constituents specified in the present invention, diverse components used in the past may be contained in bakery goods, baked goods, snack goods and meat products, such as starch (e.g., wheat starch, corn starch, or rye starch), protein, meat constituent, conventional triglyceride fats or oils, fruits, nuts, egg, milk constituents, sugar and glucose (syrup). Furthermore, a tiny amount of constituents, such as antioxidants (tocopherols naturally present or added, citric acid or its salt, ascorbic acid or its salt, hydroxytoluene butyrate, anisole butyrate, quinine butyrate, etc.), spices, salt, herbs, taste-improving agents, vitamins (especially fat-soluble vitamins, etc.), proteins, buttermilk, skim milk and emulsifiers (monoglyceride, diglyceride and lecithin).

The low-calorie food products may be final products (e.g., finished goods sold in a state in which they can be eaten immediately, and further,

intermediate products that need to be cooked in an oven, frying pan or microwave (optionally in a refrigerated or frozen state)). Suitable low-calorie food products may include puff pastries, cakes, cake mixes, dough, biscuits, potato chips, candy finished goods, chocolate finished goods, meat snacks, hot dogs, sausages, hamburger, peanut butter, spreads, deep-fried finished goods, chips, potato chips, etc. /284

The present invention will now be described in further detail through the practical examples. Unless otherwise specifically stated, percentage wholly expresses % by weight with respect to composition.

(Practical Examples)

Practical Example 1 (Experiment)

Rats were used as the model animals to test the incidence of archorrhea of oils and the severity of the interaction between liquid sucrose fatty acid polyester (derived from soybean fatty acid; inversion rate >95%) and dietary fibers having varying properties and mean particle lengths.

In the experimental period, a basic feed comprising the following composition was fed to the test animals.

Ingredients	1,000 kcal equivalent
Corn starch	163 g
Casein	62 g
Standard inorganic mixture	5 g
Standard vitamin mixture	1 g
Lard	17 g
Sunflower oil	4 g

The liquid fatty acid polyester and dietary fiber were added on top of the feed. This feed was prepared once per week and given to the animals three times per week. An unrestricted amount of water was provided.

Twelve animals were used in one set of experiments and the experimental period was 12 days. A period of 3 weeks was established between the experimental period and the subsequent experimental period. During the experimental period (12 weeks), the rating of the archorrhea decreased every afternoon (between the 3rd and 12th days). The severity of the archorrhea was rated at four levels: 0 (minimum) 1, 2 and 3 (maximum). The results published in the two tables below are based on one-hundred twenty observations, respectively.

In the first experiment, a nonfermentable dietary cellulose fiber was compared with orange pulp (primarily water-soluble natural fiber source comprising a type of easily-fermented fiber). The concentration of the liquid sucrose fatty acid polyester and the concentration of the dietary fiber were both tested, respectively. The results are shown in Table 1.

Table 1

Type of Fiber	Amount of Fiber (g/1,000 kcal)	20 g polyester/1,000 kcal severity	30 g polyester/1,000 kcal severity
Cellulose	15	1.8	2.7
Cellulose	30	0.1	1.7
Orange fiber	15	2.8	2.9
Orange fiber	30	2.7	2.9

When these results are compared with those of the fermentable fiber, the fermentable fiber clearly show a more remarkable effect as an archorrhea-preventing agent.

A nonfermentable dietary fiber commercially-available from James River Corp. under the trade name "Solka-Floc" (registered trademark) was used in the second experiment. This fiber has the varying mean particle lengths shown below.

Type	Mean Fiber Length (μm)
1	10
2	25
3	50
4	100
5	100

40 g/1,000 kcal of the liquid sucrose fatty acid polyester was added to the feed. The results obtained by adding fibers in two concentrations are shown in Table 2.

Table 2

Type of Fiber	40 g fiber/1,000 kcal		60 g fiber/1,000 kcal	
	Incidence	Severity	Incidence	Severity
1	100%	2.8	100%	2.0
2	100%	2.6	100%	1.6
3	100%	2.1	70%	0.7
4	60%	0.6	32%	0.3
5	77%	1.0	23%	0.2

The above results clearly show the effects when the mean particle length and concentration of the dietary fiber were increased.

Note the concentration of the liquid sucrose fatty acid polyester used in the animal experiment was increased considerably in order to clarify the experiment results. In addition, since considerable fiber quality levels already exist for average daily food for humans, according to the results, note the preferred fiber/polyester ratio in the food for humans may be reduced in each recipe of the food product.

Practical Example 2 (Food Product Manufacturing Example A) /285

Two kinds of cake mix compositions were manufactured in accordance with the following recipe.

Ingredients	I	II
Wheat flour	42.9%	39.9%
Butter Modifier	1.6%	1.6%
Sugar	35.8%	33.8%
Baking powder	1.6%	1.6%
Salt	0.5%	0.5%
Triglyceride fat (semihardened palm oil	17.6%	12.6%
Sucrose fatty acid polyester (I)	-	5.0%
Cellulose fiber (2)	-	5.0%

(1) Food product derived from completely hardened palm kernel fatty acid blend. Invert ratio: >95%

(2) Solka-Floc (registered trademark; commercially-available from James River Corp.) type UF-900; mean particle length: 100 µm

125 g egg were added respectively to the two types of cake mix compositions (400 g). Then a small amount of water was added in the case of the composition II to make a homogeneous dough, and baked for about 50 minutes in a conventional oven at 165°C. The resulting two types of cakes were good-quality and had comparable consistency, texture and taste.

Practical Example 3 (Food Product Manufacturing Example B

Three kinds of beef burger compositions were manufactured in accordance with the following recipe.

Ingredients	I	II	III
Meat (25% fat)	81.0%	-	-
Meat (10% fat)	-	66.0%	66.0%
Finely chopped onion	10.9%	10.9%	10.9%
Spice composition	1.3%	1.3%	1.3%
Water	2.2%	2.2%	2.2%
Rusk/[illegible] OIL	4.7%	4.7%	4.7%
Sucrose fatty acid polyester (1)	-	10.0%	-
Sucrose fatty acid polyester (2)	-	-	10.0%
Cellulose fibers (3)	-	5.0%	5.0%

(1) Food product derived from hardened blend. Invert ratio: >95%

(2) Blend of 62% completely hardened palm kernel fatty acid and 38% completely hardened palm oil fatty acid. Invert ratio: >95%

(3) Solka-Floc (registered trademark; commercially-available from James River Corp.) type UF-900; mean particle length: 110 μm

About 60 g patties were pressed on a burger press manually and grilled until the inner temperature reached 70°C.

These food products had substantially equal quality, but the loss from cooking was somewhat less in the fiber-containing burger.